UNIVERSITY OF MICHIGAN
OCT 5 1958
EDUCATION LIBRARY

Univ. of Michigan
General Library. O#68688
Ann Arbor, Mich.

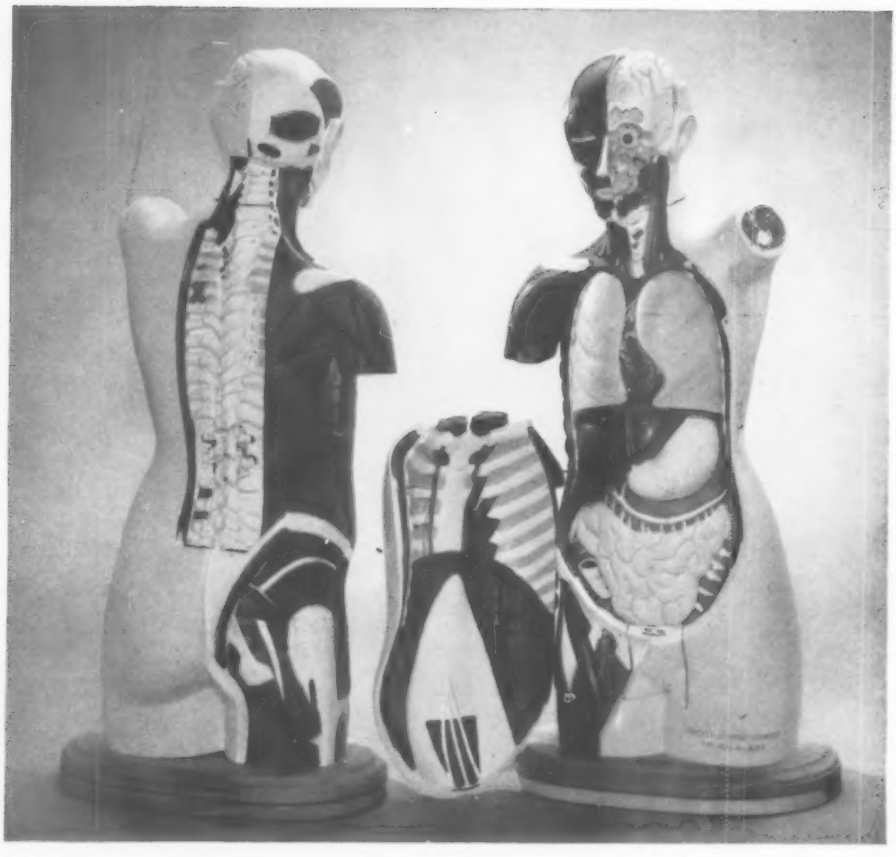
The American Biology Teacher

OCTOBER, 1958 VOLUME 20, No. 6

The Cockroaches

Outdoor Laboratory Series

Growth and Variability



BIOCRAFT

MODELS
CHARTS
SKELETONS
SLIDES
MOUNTS
SPECIMENS

DENOYER-GEPPERT COMPANY

5241 RAVENSWOOD AVENUE CHICAGO 40, ILLINOIS

The models mentioned above are made of unbreakable plastic. They are truly permanent teaching equipment, as are the charts we offer in durable mountings. Denoyer-Geppert Company specializes in visual teaching materials that can be expected to do their job of effective visual presentation for many years. In spite of the extra durability advantage, prices are reasonable. Write for Catalog 57B if don't have it.

TABLE OF CONTENTS

Unheralded Nobility: The Cockroaches 187
Frank N. Young and Irving J. Cantrall

Announcing a New Series: Studies for Outdoor Laboratories 192

Preparing for a Land-Use Survey of School Grounds by a Biology Class 193
John W. Brainerd

I Teach Biology by T.V. 197
Helen Drugg

Books for Biologists 199; 210

What Does a Fishery Biologist Do? 200
Kenneth D. Carlander

Pine Hills Area—A Relic of the Glacial Age 203
S. G. Glidden Baldwin

Growth and Variability—A Laboratory Experience 208
John E. Butler

Biology Field Trip—One Foot Away 211
Murvel R. Garner

Cover Photograph

This fine photograph of Ghost Flower or Indian Pipe, *Monotropa uniflora,* was taken by Louis F. Vogel, Science Department Editor of D. C. Heath and Co. Data: Leica 11F 135 mm. Hektor, f11 at 1/100 sec., Kodak Tri-X film, at Lovell, Maine.

THE AMERICAN BIOLOGY TEACHER

Publication of the National Association of Biology Teachers.

Issued monthly during the school year from October to May. Second class postage paid at Danville, Illinois.

Publication Office—Interstate Press, 19 N. Jackson St., Danville, Ill.

Co-Editors—RICHARD ARMACOST, Department of Biological Sciences, Purdue University, West Lafayette, Ind.; PAUL KLINGE, Coordinator for School Science, Indiana University, Bloomington, Indiana.

The Purdue University address will be the official editorial office. Manuscripts and all publication material may be sent to either of the Co-Editors.

Managing Editor—MURIEL BEUSCHLEIN, 6431 S. Richmond, Chicago 29, Ill.

Subscriptions, renewals, and notices of change of address should be sent to the Secretary-Treasurer, PAUL WEBSTER, Bryan City Schools, Bryan, Ohio. Correspondence concerning advertising should be sent to the Managing Editor.

Annual membership, including subscription, $3.75, subscription to Journal, $3.75, individual copies, $.50, outside United States, $4.50, individual copies, $.50.

NABT Officer Nominations

President-Elect	Dr. Dorothy Matala Iowa State Teachers College Cedar Falls, Iowa
	Dr. Howard Weaver University of Illinois Urbana, Ill.
First Vice President	Dr. Emery Will State University Teachers College Oneonta, N. Y.
	Dr. H. Seymour Fowler Pennsylvania State University University Park, Pa.
Second Vice President	Lorenzo K. Lisonbee Camelback High School Phoenix, Arizona
	Dr. Robert A. Bullington Northern Illinois University DeKalb, Illinois
Third Vice President	Robert L. Smith DeKalb High School DeKalb, Illinois
Secretary-Treasurer	Paul V. Webster Bryan City Schools Bryan, Ohio

MEMBERSHIP APPLICATION

NATIONAL ASSOCIATION OF BIOLOGY TEACHERS

Name_____
(Please Print)

Address_____

_____

Dues: $3.75 a year, including subscription to

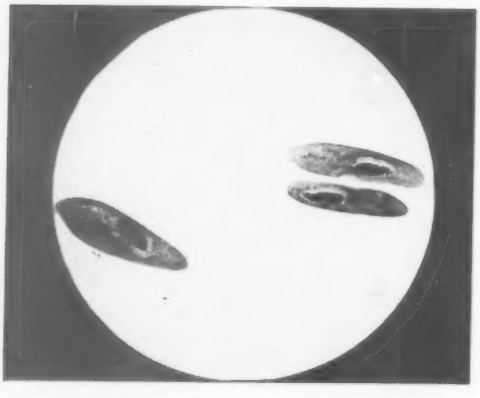
THE AMERICAN BIOLOGY TEACHER
For one year (8 issues)

Send application to:

Paul Webster, Secretary-Treasurer
Bryan City Schools, Bryan, Ohio

PLASTIC SKELETONS, SKULLS Durable, extremely realistic reproductions. Every bone in Clay-Adams plastic skeletons is cast individually in natural color, in mold impressions taken from a normal human specimen. They are easily cleaned, and individual parts may be quickly replaced.

Which of these Clay-Adams teaching aids can you use?



MBH 35 Paramecium caudatum, 65x

MEDICHROMES®

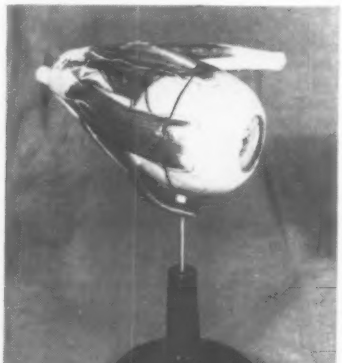
Finest 2 x 2″ Kodachrome presentations, prepared with the cooperation of recognized experts. More than 70 series available, including:

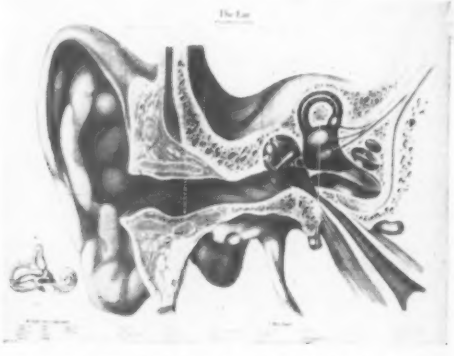
BIOLOGY (Series MBH). 530 slides made with the cooperation of Dr. A. M. Weckstein, Barringer High School, Newark, N. J. Selected to accompany Weckstein-Poster's *"Directed Activities in Biology,"* published by Oxford Book Company.

BOTANY (Series MBT). 103 photomicrographs for instruction in general botany, made with the cooperation of Dr. D. A. Johansen, Pomona, Calif.

ANATOMICAL MODELS

Large scale, anatomically accurate models of the human ear, eye, heart, and other organs are accompanied by detailed descriptive keys. Models are dissectible into component parts for more detailed study. They have been widely used as teaching aids for many years.





ANATOMY CHARTS Frohse, Schick, Michel, Bachin color wall charts of all human organs, systems, structures. Various types of mountings and cases are available.

Also available,
BOTANICAL and ZOOLOGICAL MODELS

PLEASE WRITE FOR
COMPLETE DESCRIPTIONS and prices on these and many other visual teaching aids.

Clay-Adams
141 East 25th Street, New York 10, N. Y.

Unheralded Nobility: The Cockroaches

FRANK N. YOUNG, *Department of Zoology, Indiana University*
IRVING J. CANTRALL, *Museum of Zoology, University of Michigan*

The great bard of Avon, for all his command of English was deprived of one of its most expressive words. "Cockroach" according to the best authorities only slipped in, probably as a corruption of the Spanish *cucaracha*, about 1624 some eight years after Shakespeare's death. Still, we can assume that he would have found it useful if it had been available. One of the merry wives might well have said: "Oh, thou despicable eater of dirt, low-living, vile, unfettered beast. Better had I wed a cockroach!" Indeed, "cockroach" has come to symbolize for us a netherworld creature of incredible vulgarity—a symbol of filth, poor housekeeping and unkempt conditions generally.

Along in the early 1800's there was an attempt to clean up certain words in the English language. "Cock" became "rooster," and since "Roosterroach" seems an improbable combination, "cockroach" became simply "roach." The latter, of course, is a fish, so back we go in later years to the immodest form. No one seems to like our little friends. The German roach or croton bug is known in Russia as the Prussian roach, and in Prussia, naturally, as the Russian roach. The fact is that no one really knows where our cosmopolitan household cockroaches came from except in the most general way, and we have another excellent argument for the use of scientific rather than vernacular names. The only trouble is that this reversed national pride has run over into the technical names too, and all is chaos.

Despite the semantic overload of their name, the cockroaches do not merit the repugnance in which they are held. One would have to look long to find a group of animals more fastidious in their feeding and personal habits. During the time that they are not eating, courting, running about or doing the unknown things which cockroaches do, they are forever preening and cleaning their antennae, legs, and bodies. Their record as carriers of disease is greatly overrated, and as scavengers they do much to make the world neater and cleaner.

Furthermore, the cockroaches have a real claim to nobility. We cannot like the Poohbah tell you that they trace their ancestry back to a blob of primordial ooze, but they get so close it is uncomfortable. The first fossil blattoids, hardly distinguishable in major features from those living on the earth today, are found in the Pennsylvanian rocks of the Coal Age. These rocks are estimated by geologists to be at least 250 million years old. In contrast, the "Oak Apes," which none of us would care to claim as close relatives, are a mere 30 million years old, and something like *Periplaneta* must have been kicking around for about 249,000,000 years before even a caveman appeared on the scene. No wonder a cockroach stands and gazes with quiet poise when you turn on the kitchen light and challenge his right to the bread crumbs you are too slovenly to clean up after that midnight snack!

Many of the Coal Age blattoids were not much different from modern forms. They underwent an incomplete metamorphosis after hatching from eggs in capsules just as do most of their descendants today. Both the nymphs and the egg capsules have been found as fossils to prove this. The wings of the adults were already essentially of the type of modern forms, with the hardened forewings turning over the back when at rest and the hindwings folding fan-wise beneath them. The legs were adapted for running, and many other body features were already present. Of their colors, we know nothing, but their size was about the same as that of living species—some were small, some large. Probably none rivaled the tropical giant, *Blaberus craniifer*, which has found a suitable home in Key West.

In the ages which followed the Carboniferous, the blattoids underwent a series of adaptive changes. Some branch probably gave rise to the termites which went on to develop one of the most astounding social organizations found on our planet. Others retained the primitive form of the coal forest types.

We can only assume that they found their way of life successful, since they spread out into all the warmer forests of the world without bothering to change into anything else. Today we find them "wild" from Canada to the Argentine, and it is not surprising that when man came along and began to push his particular tropical microclimate into all sorts of unlikely places some of the cockroaches went along. It is amazing, however, that out of the approximately 450 genera and 3500 different species now known, that so few kinds have chosen to enter human dwellings.

The vast forests of South and Central America are the home of a large and varied assemblage of roaches. Some have developed colors to rival butterflies. Others resemble beetles so closely that we can only suppose that they derive some benefit from the resemblance. The little emerald pieces of living foliage which we occasionally find in fruit stores or wild in the far south represent only a fragment of a great group of green species. The variety seems endless, but not a one has given up that underturned blattoid head which we first see impressed in the Pennsylvanian and Permian shales.

Nearly every major subfamily or family group of cockroaches is represented in the United States, but only about six species make up the majority of the individuals seen in houses. Two of these, *Blattella germanica* and *Blatta orientalis*, are cosmopolitan in distribution; the others *Supella supellectilium*, *Periplaneta americana*, *P. australasiae*, *P. brunnea* are circumtropical. The Periplanetas are often found "wild" and so can gain access to a house by simply walking across the threshold. Others are normally carried from place to place in the products of man.

The following "Key" is designed as an aid to the recognition of some of the cockroaches commonly found in houses or other buildings. Many other species doubtless occur, particularly in summer camps and other edifices surrounded by the out-of-doors. More technical keys covering the United States species, both wild and edificarian, can be found in papers by John W. H. Rehn and by Morgan Hebard in *Entomological News*, Volume 61, 1950, and *The Memoirs of the American Entomological Society*, No. 2, 1917.

We have tried to keep the technical terms to a minimum and to use characters visible to the naked eye. With care, however, most of the species should be determined by using the key in connection with the figures. Start by taking the specimen "in hand" and reading the line of the key marked "1." If the characters given there and the figure coincide you have identified your specimen as "*Blaberus craniifer*" described many years ago by Burmeister. If the characters do not fit, read the line marked "1'." This will lead you to line "2" and so on through the key. Each numbered set of lines contrasts so that by a process of bifurcation you eventually reach the name of a species which can then be checked against the figure. Some species appear in the key twice, since some characters are variable or subject to different interpretations. You will need a small ruler graduated in millimeters, but a lens should not ordinarily be necessary.

Some of the characters cannot be seen if your specimen is a nymph or immature roach. The wings do not usually develop until sexual maturity has been reached. Do not try to key out very small and wingless specimens, since it is usually a waste of time.

The *tegmina* are the hardened fore-wings, which lie flat on the back when the cockroach is at rest. The *pronotum* is a convex plate which lies in front of the bases of the wings and partially or completely covers the underturned head. The *disk* or central portion of the pronotum is often differently colored from the margins. If you need to tell males from females, the females have only seven visible abdominable segments when viewed from below while the males have nine.

Key to Some Adult Cockroaches Often Found in Houses

1. Tegmina or forewings over 40 mm. in length; pronotum with a dark discal shield with lighter markings suggesting a face; see figure 14. ..... The Giant Cockroach, *Blaberus craniifer* Burmeister.

   A large tropical species introduced into Key West, Florida, and now often found in houses or even "wild" there.

1.' Tegmina less than 40 mm. in length.....2

2. Tegmina more than 21 mm. in length.....3

2.' Tegmina less than 21 mm. in length.....5

3. Tegmina reddish-brown with the outer portion of the front edge strikingly yellowish in color; pronotum with two sharply defined dark areas; see figure 3.....The Australian Cockroach, *Periplaneta australasiae* (Fabricius).

Another tropical species now widely distributed, but probably originally from Africa. It is common in the southern United States.

3.′ Tegmina all one color (unicolorous).....4

4. Pronotum with two very vague dark blotches and the posterior edge usually decidedly darkened; tegmina of male 24.3 to 29.9 mm. in length; tegmina of female 23.8 to 26.5 mm. in length; see figure 5.....The Brown Cockroach, *Periplaneta brunnea* Burmeister.

A fairly common species in the South.

4.′ Pronotum with two fairly evident dark blotches which may be partially fused together and posterior edge only slightly suffused with dark color; tegmina of male 29.6 to 35.1 mm. in length; tegmina of female 23.9 to 28.4 mm. in length; see figure 1.....The American Cockroach, *Periplaneta americana* (Linnaeus).

Another African which has travelled widely and is now one of the commonest household pests in the eastern United States.

5. Tegmina not reaching tip of abdomen....6

5.′ Tegmina surpassing tip of abdomen.....10

6. Length of body 30 mm. or over; tegmina about 9.5 mm. wide; see figure 19.....The Palmetto Bug, *Eurycotis floridana* (F. Walker).

A large species which has a distinct odor of maraschino cherries when disturbed. Found only in Florida in the United States.

6.′ Length of body less than 30 mm.....7

7. Tegmina small, oval, widely separated pads; See figure 23.....females of *Blatta orientalis*, Linnaeus.

This is the "black beetle" of the English. They are the most offensive of the species found in the United States, but live mostly in basements or around sinks. They are also called "water bugs."

7.′ Tegmina touching each other or decidedly overlapping 8

8. Tegmina only as long as or slightly longer than pronotum; see figure 15.....females of some *Parcoblatta*.

These are native Woods Roaches of which there are many species which may get into houses.

8.′ Tegmina longer, at least two-thirds the length of the abdomen 9

9. Entire pronotum dark brown, unicolorous; see figure 22 .....males of *Blatta orientalis*, Linnaeus.

9.′ Pronotum contrastingly bicolored, the dark color of the disk extending completely from front to back; lateral lobes of pronotum transparent or only slightly opaque; tegmina usually contrastingly marked with light and dark areas; size smaller, length of body 10 to 12 mm.; see figure 11.....The Brown-banded Cockroach, females of *Supella supellectilium* (Serville).

A tropical species which has spread rapidly to the north in the United States in recent years.

10. Pronotum marked with decidedly contrasting colors 11

10.′ Pronotum unicolorous or with the color fading outwardly from the disk to the more lightly shaded or transparent lateral portions .....12.

11. Disk of pronotum pale brown with two longitudinal dark brown stripes separated by a yellowish stripe; length 12 to 15 mm.; see figure 13 .....The German Cockroach or Croton Bug, *Blattella germanica* (Linnaeus).

This insect probably came from the Old World tropical regions, but certainly not from Germany. It is now cosmopolitan and one of man's most faithful associates.

11.′ Dark color of disk of pronotum extending completely from front to back of pronotum, not divided into stripes; lateral lobes of pronotum transparent or but slightly opaque; length of body 10 to 12 mm.; see figure 9.....The Brown-banded Cockroach, males of *Supella supellectilium* (Serville).

12. Color greenish; length about 15-20 mm. see figure 4 ..... *Panchlora cubensis* Saussure.

A tropical species occasionally found in Southern Florida. Other green cockroaches occasionally show up in fruit stores.

12.′ Color black, brown, or tawny not green; length about 12-15 mm., see figure 20 ..... males of Woods Roaches, *Parcoblatta*.

Some of the less common roaches sometimes found in houses are shown in the plate. Among them, figure 12 shows the large *Leucophaea maderae* (38-58 mm. long) which has only recently appeared in the United States. It is said to be common in Harlem in New York City. *Periplaneta fuliginosa* (figure 16) is common in the South but extends north at least as far as Indiana in

houses. It is distinguished from the other Periplanetas by its darker, almost black, color.

The smaller roaches on the plate are mostly from the Everglades region of Florida and do not occur commonly elsewhere in the United States. One of these, *Pycnoscelus surinamensis* (figure 2) is very common around Miami. It is similar to *Leucophaea* in being a live bearer, that is the egg capsules are retained within the female until they hatch and the young are thus born alive.

Many of the tropical forms which have been introduced are domiciliary or house-living types, but when one considers the types of dwellings in tropical and sub-tropical areas a question arises as to just how one differentiates a "wild" cockroach from one adapted to living in homes. Thus at Key West, *Leurolestes pallidus* (figure 21), *Holocompsa nitidula* (figure 17), and *Blaberus craniifer* (figure 14) have been collected under domiciliary conditions, but *Blaberus* has also been taken outdoors and is sometimes very abundant in the hammock on Stock Island. The others also may well occur out-of-doors, and the line between house-dwelling and "wild" species seems very thin. Further collecting and a study of the habits of the little-known cockroaches may well change many of our ideas.

Our native roaches are all considered to be "wild," but individuals are often found in houses. These are only accidental and will soon leave or die. The smaller species such as *Chorisoneura texensis* (figure 10, are usually found in leaf litter or in sheltered places under bark and logs. At night they come forth and run about on tree trunks, leaves, and twigs or on the ground. Species such as *Latiblattella rehni* (figure 6), *Parcoblatta fulvescens* (figures 15-20), and *Ischnoptera deropeltiformis* (figure 7-8), need larger places of concealment, and at night range farther from their daytime hiding places. The large *Eurycotis floridana* (figure 19), is least restricted of all to leaf mold and litter, and may be found concealed beneath loose bark, behind signs, in holes in trees, or even in the solution cavities in limestone.

The real collector's items in the North American list are mostly the species found on the Florida Keys and, therefore, do not occur very far north. The interesting little *Plectoptera poeyi* (figure 18), has been found at Key West and on Big Pine Key. It is apparently one of the few really "wild" species being found running about on the stems and foliage of bushes at night.

Since the cockroaches are easily reared in cages in the laboratory, they have been used in recent years for many types of biological experiments. The large Cuban *Byrsotria* is now sold by supply houses and can be easily kept and reared in ordinary aquaria or almost any tight cage. It has the great advantage of not wandering about much so that it seldom escapes. If it does a 2-inch cockroach is almost sure to attract attention so there is little danger of its becoming a pest. In the lab they do well on ordinary dog biscuit or dog meal with an occasional apple slice as supplementary fare.

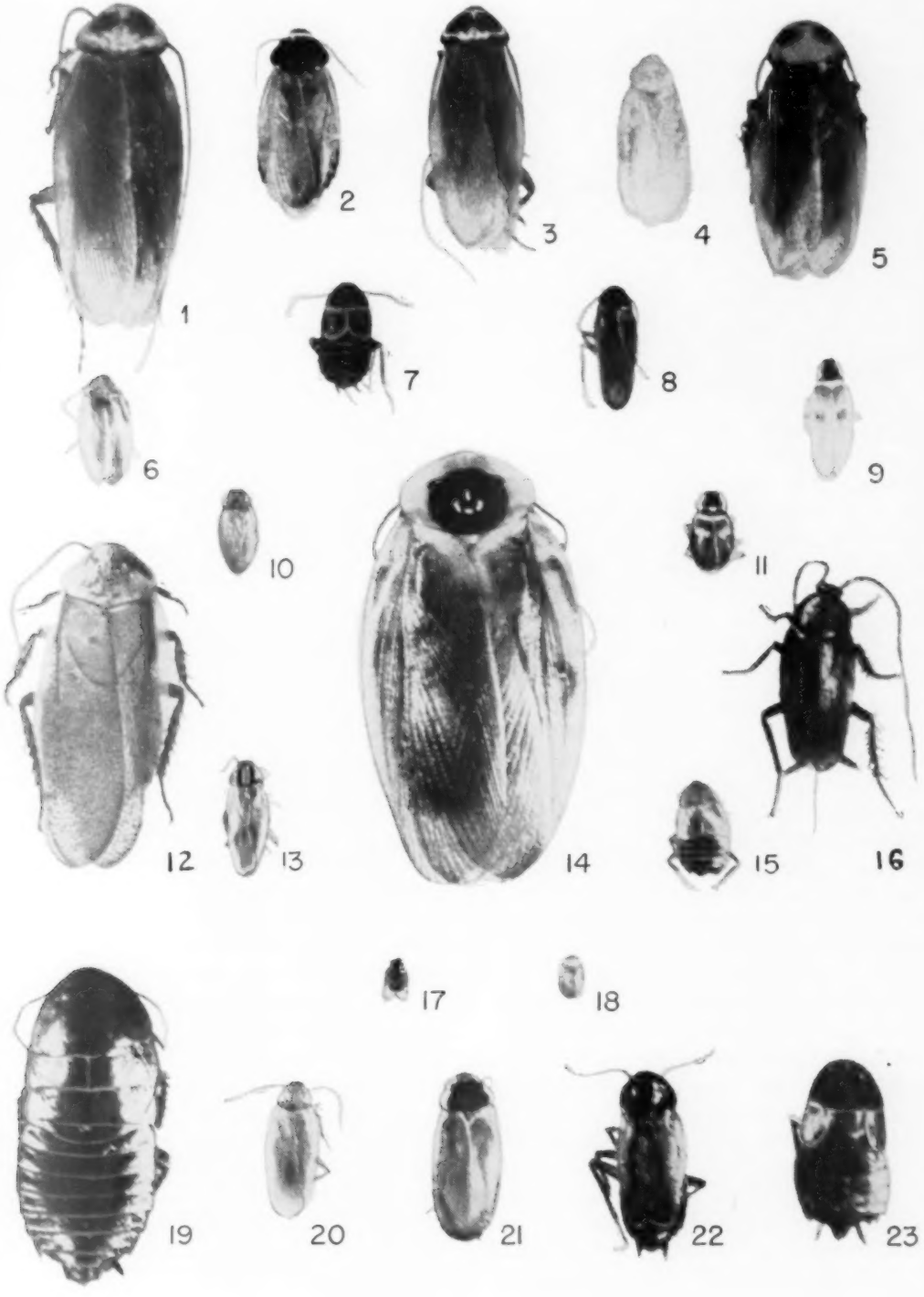
Living cockroaches can be used in teaching in many ways. Observations can easily be made on moultings, growth, development of the wings and other features of the life cycle. Reactions to light, sound, and air currents can also be demonstrated. Furthermore, a freshly killed specimen is unexcelled for demonstrating internal anatomy. The trachea tubes show up beautifully, and many structures difficult to see in preserved specimens can be readily identified.

A Word About Cockroach Control: The indiscriminate slaughter of our noble friends is opposed to our general philosophy of nature, but for that matter some people obviously need control. The United States De-

SOME COCKROACHES FOUND IN THE UNITED STATES

1. *Periplaneta americana* (Linnaeus)
2. *Pycnoscelus surinamensis* (Linnaeus)
3. *Periplaneta australasiae* (Fabricius)
4. *Panchlora cubensis* Saussure
5. *Periplaneta brunnea* Burmeister
6. *Latiblattella rehni* Hebard
7. *Ischnoptera deropeltiformis* (Brunner). Female
8. *Ischnoptera deropeltiformis* (Brunner). Male
9. *Supella suspellectilium* (Serville). Male
10. *Chorisoneura texensis* Saussure and Zehntner
11. *Supella supellectilium* (Serville). Female
12. *Leucophaea maderae* (Fabricius)
13. *Blattella germanica* (Linnaeus)
14. *Blaberus craniifer* Burmeister
15. *Parcoblatta fulvescens* (Saussure and Zehntner). Female

16. *Periplaneta fulignosa* (Serville)
17. *Holocompsa nitidula* (Fabricius)
18. *Plectoptera poeyi* (Saussure)
19. *Eurycotis floridana* (F. Walker)
20. *Parcoblatta fulvescens* (Saussure and Zehntner). Male
21. *Leurolestes pallidus* (Brunner)
22. *Blatta orientalis* Linnaeus. Male
23. *Blatta orientalis* Linnaeus. Female



partment of Agriculture has issued a very useful bulletin—Leaflet No. 144, *Cockroaches and Their Control*—which can be obtained free of charge from your local congressman or senator. This bulletin outlines the methods of extermination and the effective chemicals and their uses.

Even in the face of relentless attack, however, roaches are a persistent lot, so be prepared to repeat your treatments from time to time. After all, our unheralded nobility has been around for a long time and passed almost unchanged through the ages that eliminated the trilobites, dinosaurs, and sabre-toothed tigers. They are tough, so don't be surprised if they merely sneer at the feeble products of the biochemists.

Announcing
Studies for Outdoor Laboratories
A New Series

At the Indianapolis meetings, the NABT Conservation Committee and the Editorial Board of *The American Biology Teacher* agreed to launch a series of articles to promote the use of outdoor laboratories by biology teachers. The first of the series is included in this issue of the Journal.

This series will be the major effort of a sub-committee on Outdoor Laboratories, under the leadership of Dr. Richard L. Weaver, School of Natural Resources, University of Michigan, Ann Arbor, Michigan. *Authors for parts of the series are needed*, and contributions should be sent to Dick Weaver.

Two other conservation sub-committees were organized at Indianapolis. One on *suburban conservation* will be under the leadership of Dr. E. L. Palmer, 206 Oak Hill Road, Ithaca, New York. The other one will be on *urban conservation* and the chairman of this sub-committee is Dr. Emery Will, State Teachers College, Oneonta, New York. Requests for specific help for these two additional projects will soon be forthcoming. If interested especially in these, write to the chairman immediately.

Suggestions to Contributors for Outdoor Laboratory Series

Articles should be especially helpful in correlating outdoor laboratory work with current classroom work, supplementing the NABT CONSERVATION HANDBOOK.

A great variety of subjects await authors. Some will want to take an environmental approach, writing on how to study a lawn, foundation planting, or marshy spot behind the ball field. Some will take an organismic approach, describing how to study robin populations, Japanese beetles, or Kentucky bluegrass. Others may take a managerial approach, dealing with agricultural, horticulture, silviculture, or wildlife management as application of biology to the school grounds or to other properties available. Manifold other approaches include such inviting avenues as evolution, genetics, and physiology. Some authors will emphasize descriptive biology and others experimental biology.

Given so much freedom of subject and approach, authors should not object to some editorial regimentation in this series. The following topics are suggested:

SCENE: Name, type, and location of school. Season and duration of study.
PURPOSE: (short and to the point).
CLASSROOM PREPARATION:
OUTDOOR ACTIVITY AND CORRELATED CLASSROOM WORK:
CLASSROOM FOLLOW-UP AND RESULTS:
APPENDIX: LITERATURE, AUDIO-VISUAL AIDS, RESOURCE PEOPLE, EQUIPMENT, MATERIALS.

Authors can help the editors by following suggestions outlined by John Breukelman in "Preparation of Manuscripts for Publication," *The American Biology Teacher* II:7 (174-180), November, 1949. The four pages hold about 2800 words (eight 350-word columns), but it is best to use some of the space for glossy black-and-white photographs and diagrams of apparatus, maps, and other line drawings combining instruction and decor—Start writing! !

Outdoor Laboratory Series—Number 1

Preparing for a Land-Use Survey of School Grounds by a Biology Class

JOHN W. BRAINERD
Professor of Biology, Springfield College, Springfield, Mass.

Almost any existing junior or senior high school with any grounds, even though almost completely paved, can profit from a constructively critical review of its grounds. A biological approach can be particularly rewarding. A land-use survey can increase the students' understanding of the importance of natural resources to the human animal and at the same time help insure samples of such resources for future study at the school. Herein lies a great challenge for biology teachers.

Now is a good time to prepare for this educational venture; for whatever the current topic in the biology text may be, it must have its correlations with man's relationships to his environment as they can be observed on the school grounds. And to study these relationships outdoors occasionally adds verve to classroom work, heightening student interest and desire to learn. No matter if the weather be bad; there is much indoor preparation before effective work can be done outdoors. For instance, one can be introducing the following concepts in more or less detail, either as briefly suggested here or in some other way, until the weather is good.

A Few Important Ecological Concepts

Organisms have a physical environment with many factors. Use the classroom as an example, by studying its atmosphere used by the students. Measure air temperature at floor, five-foot, and ceiling heights in various parts of the room. Measure relative humidity. Using smoke, milkweed seeds, or downy feathers, compare the circulation of air when windows are opened at the bottom with when they are opened at the top; then discuss the relative effects on the comfort and alertness of the students and teacher. Let students make maps and diagrams of the microclimates of the classroom and assign a similar study of one room at home. *Organisms modify their physical environment.* Arrange to have another class crowd in with yours to see the film YOURS IS THE LAND. Have your class measure the air temperature and relative humidity just before their arrival and after their departure. Evolve an hypothesis about what all those students did to the air in your room. *Animal behavior may change as physical factors of the environment change.* Secretly arrange to have a few students study the conduct of other students when a normal number are asked to do chalkboard work and then when a greatly overcrowded number are asked to do chalkboard work and then when a greatly overcrowded number are asked to work on the same area. Then discuss.

Animal populations are partially controlled by inherited responses to environmental factors. For instance, many establish territories for their use and defend them against use by others. Read Wallace, pp. 126-134. Show the film BOB - WHITE THROUGH THE YEAR. Note that man himself may try to defend his land first by noise and then by force; occasionally he uses reason.

Man has the most highly evolved central nervous system of any animal. How can he use his cerebrum so as to share the resources of his environment for "the greatest good for the greatest number for the longest time?" Discuss the sharing of classroom resources such as light, atmosphere, seats, writing surfaces, walking space, and quietness; also educational resources such as books and maps. Don't neglect the human resources, teacher and students, which make the difference between a school and a school building. Let the children try to devise a better arrangement of any movable components of the classroom, for a day or a week; then let them try to study the effects of the modified environment upon their own behavior. Has their intelligence proved superior to that of those who had planned the prior arrangement? What are the criteria for judging? Who should decide how the room is to be arranged? Is the majority always right in deciding use of resources?

All natural resources are interrelated. Our

environment is a vast complex of the energies and materials of atmosphere, land, and water, with some of these miraculously joined to form living plants and animals. The soil has all these ingredients. Time and space are also resources of great import, which the human animal can either waste or use wisely. Using aerial photographs and maps, discuss how your school's community is laid out to take care of the biological needs of its members. Note areas for transportation of food, of materials for shelter, and of other biologically important commodities; note areas of productive soils, of watersheds, and of sewage disposal facilities; note areas for rest and recreation. Show the film TO CONSERVE OUR HERITAGE.

Preliminary Outdoor Observation

Reconnaisance. When the weather is nice, take the class on a quick trip around the school grounds. Note their boundaries, natural resources in general, and the primary patterns of land use. The latter will probably include areas for locomotion (drives and sidewalks); parking for automobiles and bicycles; space for the building; areas landscaped primarily for beauty, soil stabilization, and safety; service area, as for trucks, incinerator; play areas, especially for organized sports. Also give attention to any odd corners which seem to be in disuse, for these may become very important to your biology class if your land-use survey brings results!

Conduct of the first field trip is worth special consideration. It should be businesslike. Students must learn to get joy from being outdoors at school without recourse to undue foolery and slackening of intellectual endeavor. Each sortie should have a purpose related to classroom efforts. This first field trip can even be a formal two-by-two marching in silence if there has been adequate previous discussion of boundaries, natural resources, and primary patterns of land use. Challenge their powers of observation and memory; have them leave note-taking materials in the classroom. The distance and duration of the trip will depend on the extent of the grounds.

Classroom Follow-Up

Discussion should give students the joy of reporting observations but should also bring out the inadequacy of such a brief survey. The following are questions which may be raised.

Sidewalks and Lawn. Are the sidewalks wide enough? Does lawn grass fail to grow close to the walk? Is soil washed or blown away along the walk? What factors of land-use is incompatible to the life processes of the grass? How could this be proved or disproved experimentally by biologists?

Wildlife and Land-use. Was any wildlife seen on the trip? If so, what was it doing and did its activity relate to a biological need? Was the need being filled by the environment? What kinds of animals could be expected if more food, cover, and/or water were supplied on the school grounds? Could these animals be of interest in the study of biology?

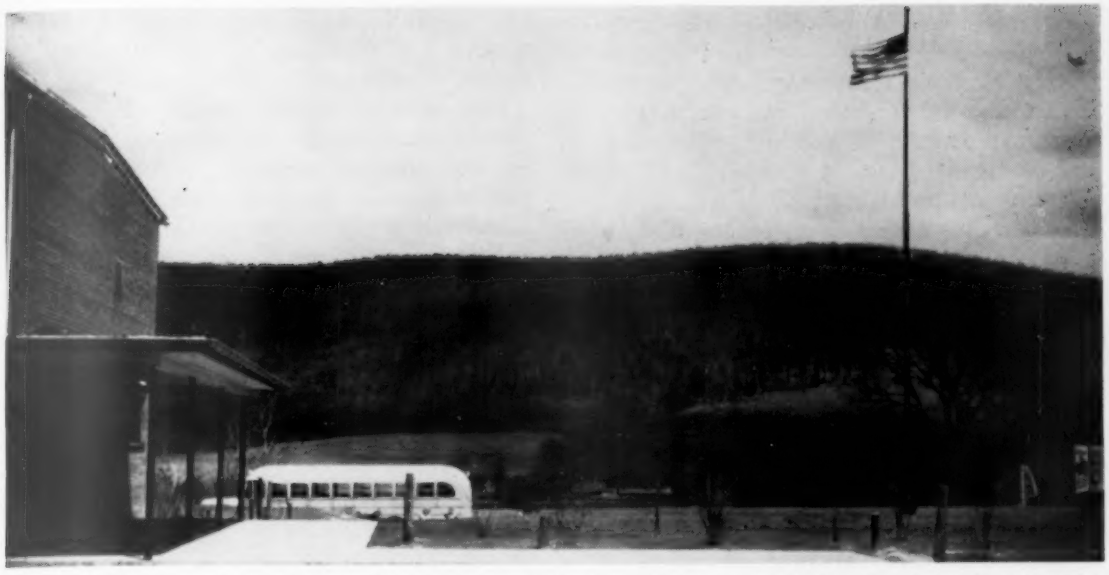
Water. Was any indication seen of what happens to the water falling on the school roof? Were there any signs of temporary run-off anywhere on the grounds, for instance deposits of rain-washed seeds along a curb or rill marks on bare ground, or erosion of a bank? Did the plants indicate that there is more ground water available at one place than at another, and if so is it because of topography, soil porosity, vegetation, microclimates, some other factors or combinations of these factors? Could we improve the water resources of the school grounds by changing any of the environmental factors?

Single versus Multiple Use. Was each land-use area used for a single use or did it have multiple use? Was the paved area used for play as well as for parking, and how compatible are these uses? Was the lawn used for learning as well as for looks? Could the baseball backstop be used experimentally for growing vines without impairing its primary function? If an area has multiple use, is one use always primary while the others are secondary, from the point of view of the school as a whole? Should the school as a whole be considered? Who makes decisions about land-use at the school anyway? Who is responsible?

Stop the discussion while it is still going strong. A homework assignment should let each student reveal what aspect of the school grounds is of most interest to him; it should also involve biological principles.

An Outdoor Laboratory?

Now wait until the students suggest further studies of the school grounds. This may be stimulated by posting clippings of what



Matternville School, Pennsylvania. The lawn was built by students who wheelbarrowed in the dirt. The students planted shrubs and set in posts to protect them. The posts were used for leap-frog.

other schools have done or literature from the Nature Conservancy's National Committee on Natural Areas for Schools, or by leaving the NABT CONSERVATION HANDBOOK lying around open to Chapter Six, or by taking a couple of the class leaders on a Saturday trip to a nature sanctuary. When the suggestion comes, be "hold-offy." Explain the amount of biological material to be covered by June and the advantages of working indoors with protection from wind and rain, with control of temperature and light, with places to store equipment and materials. What has an outdoor laboratory got than an indoor one doesn't have more of? They just want to play! . . . When you have convinced them of your narrow stupidity and frustrating obstinacy, ask for volunteers from the better students to skim ahead in the text, each taking a chapter and listing possible activities on the school grounds which would correlate. Let them use the NABT CONSERVATION HANDBOOK. Any field work for this listing should be done on their own time, unless an advanced student can be released from class activity to check on some aspect of the school grounds. . . . Perhaps you can be convinced in a couple of weeks that your school should have an outdoor laboratory!

Have the class form temporary committees to map the entire school grounds. Not only will this result in a land-use map indicating which parts can be specially set aside for class use, but it will give a base for future biological censuses, experiments, and management. Good work at this stage saves many headaches later. Related committees prepare for systematic filing of data, a necessity for long-term scientific work but too often lacking in the training of scientists. Set a completion date a month or two away for committee work.

Suggested Committees

Map Procurement Committee: Tactful go-getters interested in people should try to get a copy of every existing map showing the school grounds. This may involve tracing simple maps and having prints made of more complicated ones when a spare copy is not available. They must realize that any map borrowed for copying must be treated with great care and returned soon. Sources: Principal's office, school department office, other town offices such as water department, street department, tax assessor, and planning board; local surveyor, and realtor. Old deed maps can sometimes be found at the county registry of deeds. Be sure they get at least one topographic map from the U. S. Geological Survey, even though it may not show the school grounds. Definitely get a large enlargement of a U.S.D.A. vertical aerial photograph including the school; it may take several

months to arrive, but it will prove a wonderful teaching tool.

Map Drafting Committee: Students strong in art and math should make a large-scale base map from which other types of maps can be made later. It should show as accurately as possible: Boundaries, buildings, roads, walks, utility lines, fences, and other permanent cultural features for reference, such as hilltop or prominent rock outdrops; *graphic* scale, northpoint with declination, date, and name of school.

Base maps should have all lettering kept to the absolute minimum and simple, to leave large blank areas for entering the data, keys, and illustrations on the more specialized maps to be made from it. The base map is so important to future studies that it may be wise to get help from math, art, and printing teachers or to have their classes make the map in cooperation with your committee. The base map can be made from new measurements on the school grounds, from existing maps, and/or from a vertical aerial photograph projected from an opaque projector onto a plain paper taped to a chalkboard, focused so as to give a suitable scale, and traced.

The scale will depend upon the size of the property and the size of paper which can be handled and stored (usually a maximum of about 2½ x 3 feet). Ten-scale (an inch representing ten feet) is excellent for detailed work, but on large properties one may have to compromise with, say, twenty-scale.

After the original base map is drafted, say at ten-scale, a dozen or so prints should be made at the same size as bases for other large maps for display purposes. Then a smaller-scale base map should be copied from it by reducing it to fit on 8½ by 11-inch paper. (Note that the graphic scale will still be true, unlike a verbal scale, even though the map may now be 50-scale.) This smaller base map will be much used for final reports of biological surveys; so it will pay to print 500 copies, if the map is good.

Mimeograph Committee: Less creative students but ones capable of good routine work should cut a mimeograph stencil of the small-scale base map (8½ x 11) so that it can be run off inexpensively as needed for work sheets, saving the printed maps for final reports and displays. They should also cut mimeograph stencils of the large, 5-scale base map in 8½ x 11-inch sections to use for localized studies not involving the whole area. These sections, instead of being edge to edge, should overlap with each centered on a land-use area, to minimize having to work on areas involving more than one such sectional map. These sectional maps should be numbered and their positions indicated on a small-scale base map made into an index map.

Map File Committee: Manually inclined students should make shallow shelves for storing the large maps flat, perhaps with the help of the shop teacher. (The 8½ x 11 maps will be kept in folders in a standard file if there is one available.

Records Committee: Students with secretarial interests should set up single cardboard headings for 8½ x 11 folders in a file, including: TOPOGRAPHY, MICROCLIMATES, SOIL, WATER, VEGETATION, WILDLIFE, and HUMAN USE. Then folders behind these can be labeled according to subcategories as the need develops. Eventually there should be a folder, for instance, for each species of plant and animal investigated on the school grounds. This committee should be impressed by the value in science of well-kept records available to future researchers. Since only certain capable students should ever have direct access to this file, there should be one place for deposition of to-be-filed material submitted by others. . . . This committee may also want to set up a file for 3 x 5 cards similar to the one shown on p. 41 of the NABT CONSERVATION HANDBOOK, for recording many types of biological data under suitable headings.

Photography Committee: Amateur photographers can take both black-and-white and color transparencies of the present status of the use and misuse of the school grounds, as a start to the actual survey.

Library Committee: Avid readers can compile references useful for identifying local plants and animals, for experiments with soil and water on the school grounds, for maintenance of the outdoor laboratory, and so on. This should be set up as a 3 x 5 file by subjects. They may also want to make an author file. Have them get help from a librarian. The school should then try to build up its outdoor reference library, perhaps with help

from the PTA, local garden club, or sportsmen's club.

The Land-Use Survey

With the completion of their preparatory jobs, the committees should be disbanded and teams formed for making the land-use survey according to any of several methods (Vinal, p. 29) of recording the pattern of present land use onto a large base map for permanent reference. A copy should be neatly colored to show type of land-use and posted along with the photographs for the whole school to see.

Planning Better Outdoor Laboratories

Equipped with a land-use map, in many instances the biology class should be able to recommend to school officials that certain parts of the school grounds be set aside as outdoor laboratories under the direction of a faculty-student committee, and also to recommend from time to time practices such as planting which can improve the rest of the school grounds for educational use. Herein lies a great challenge for biology teachers.

Literature

Anon., *Conservation in American Schools*, American Association of School Administrators, 1201 Sixteenth Street, N.W., Washington 6, D. C., 1951, $4.00.

Anon., *Maps and How to Understand Them*, Consolidated Vultee Aircraft Corp., New York, N. Y., 1943.

Eardley, A. J., *Aerial Photographs: Their Use and Interpretation*, Harper and Bros., New York, N. Y., 1941.

Heavy, W. F., *Maps and Aerial Photo Reading Simplified*, Military Service Publishing Co., Harrisburg, Pa., 1942.

National Association of Biology Teachers, *Handbook for Teaching of Conservation and Resource-Use*, The Interstate Press, Danville, Ill., 1955, $4.00.

Vinal, William G., *The Outdoor Schoolroom for Outdoor Living*, Publ. by the author, "Vinehall," RFD, Cohasset, Mass., 1952, $1.00.

Wallace, George J., *An Introduction to Ornithology*, The Macmillan Co., N. Y., 1955.

Audio-Visual Aids

Motion Pictures:

Bob-white Through the Year, Missouri Conservation Commission, Jefferson City, Mo., 46 min., color. Apply for loan to your state conservation department.

Yours Is the Land, Encyclopaedia Britannica Films, Inc., 1125 Central Ave., Wilmette, Ill., 22 min., color, 1950. Rental prints stocked by film libraries.

To Conserve our Heritage, Minneapolis-Moline Co. Film Library, Minn. 1, Minn., 35 min., color, 1954; loan.

Maps:

U. S. Geological Survey, Department of the Interior, Washington 25, D. C., publishes Topographic Map Index Sheets and Topographic Maps, but may refer you to a local distributor.

Aerial Photographs: Aerial Photographic and Engineering Service, Agricultural Stabilization and Conservation.

Eastern Laboratory: U. S. Department of Agriculture, Wash. 25, D. C.

Western Laboratory: 167 West Second South, Salt Lake City 1, Utah.

First order a photo index by giving your precise location on a topographic map. Then order photographs (preferably a stero-pair) from the photo index, using the Aerial Photographic Order Blank.

I Teach Biology by T.V.

HELEN DRUGG

Keene High School, Keene, New Hampshire

In July, 1957, I was called into our assistant superintendent's office. I was mystified as to the reason for this unexpected summer vacation summons. The reason? "Would you like to teach biology by closed circuit television?" he asked. Our faculty had discussed the possibilities of this new medium at some length in the spring of 1956. At that time our school applied for a grant for this pioneer program from the Ford Fund for the Advancement of Education which, incidentally, we did not receive at that time. I had done some serious thinking on the subject. The challenge of doing something new has always appealed to me. My reply? "I'm not afraid to try it."

About five weeks later I learned that $7,500 from a local fund for adventures in higher education had been made available for this pilot project with closed circuit T.V. at Keene High School, Keene, New Hampshire. Biology, in which two teachers are involved, was chosen for this experiment.

At this writing I have prepared and presented more than seventy-five telecasts. It has been fun pioneering. I'm glad I dared to venture. My class-room was made into a temporary studio classroom for the first year experiment. Our equipment consists of two Dage cameras, model 101AF (industrial type); one has a three-lens turret; the other, one. The television image is received in four rooms

on standard 21" television sets; there are two to a classroom. One of the four rooms is used for visitors. The studio lighting consists of overhead spots and banks of fluorescents and two twelve-inch scoop lights of 1000 watts each. A home-made console contains the switches, audio video mixer, and an audio mixer for additional microphones. There are ten sophomore and junior boys in the television section of the audio-visual program under the supervision of the school's audio-visual director. They received some initial instruction from the vice-president of Videonics, Inc., Cambridge, Massachusetts, who sold the equipment. But primarily, it has been learning on the job for the boys. All the boys are extremely interested in the program and in mastering the skills. Some plan television careers. They are doing a fine job and frequently come up with ideas for improving the technical aspect of the program.

Each pupil has seven periods a week in the College Biology Course. Telecasts are forty minutes long and are given on Monday, Wednesday, and Friday with a double laboratory period coming on Tuesday and Thursday.

What is a typical T.V. day like? At the start of the day two student engineers come into the studio, push back the desks, dolly out the cameras, bring the scoop lights into location, wheel the console into place, attach cords, turn on the overhead lights, and, when the cameras are warmed up, get them in focus. They test the microphones and turn on the receiver sets. In the meantime, I'm busy assembling posters, exhibits, and telecast guides for the camera boys. Just before telecast time, nine o'clock, three student engineers dash in from their first period class and check the day's plan. Now the T.V. lesson is ready to go by cable to the classrooms where some eighty-five pupils are seated. I have a live class of about twelve in the studio with me. This group I enjoy greatly for their questions and expressions help to guide me.

In each lesson I plan to involve the pupils in one way or another. On some days pupils present panel discussions, special programs, reports, or assist in demonstrations. Occasionally we have a "quiz for fun," using questions or specimens relating to class work. The Tic Tac "Zoo" is enjoyed by all! Spin the Phyla (played like Dotto) worked fine and a blind-folded panel with biological specimens to identify was a real success. When specimens relative to the lesson are used the results are excellent. Close-ups of flowers, cones, coral, fossils, insects, frog brain, in fact, all typical biological exhibits are brought to each pupil as though he had a front seat view. No more wasting time passing (sometimes dropping!) specimens too small to see well. As the pupils see the object clearly, I can readily explain interesting points.

Another excellent feature of a T.V. day is the opportunity it provides for utilizing on the telecast resource people in the community. One would hesitate to ask a busy person to come in four times in a given day to speak to small class groups, but with television a large audience and one broadcast fills the bill.

I frequently use pictures from magazines to illustrate a point in the lesson. Many of these, if colors are right, telecast beautifully, and one gets a third dimensional effect that gives that feeling of reality.

I use student assistants in each teleclass, as the teacher monitors assigned to the rooms are not biology teachers. This gives pupils a chance to develop leadership and is a possible recruiting ground for future teachers. The student assistants were selected by the pupils themselves after a number of top pupils had been given a chance to try out. More than a dozen pupils have been involved in this phase and are doing a splendid job. I ask questions pertaining to the lesson. The assistants and pupils discuss it, then I summarize relevant points. Each pupil turns in an evaluation sheet of his teleclass participation at the end of the week.

Posters used in the telecasts are made by biology pupils who take art. A mechanical paper-writing machine developed at Hagerstown, Maryland, is an excellent device and serves for writing out assignments, explaining by sketches, and spelling vocabulary words. It is far superior to a green or black board.

Audio aids are most effective for creating a real biological atmosphere. I use bird, insect, and amphibian records whenever they adapt themselves to the lesson or the season.

Feeding of classroom animals around a small cage is always fascinating! With T.V. all can see the fun as though they had entered, with Alice in Wonderland, right into the terrarium itself.

After class everyone is busy, getting the studio back to a classroom, picking up and storing away exhibits. I then turn to my plans and preparations for the next telecast.

Don't expect T.V. to do all the teaching tasks; however, many things can be presented far better with this new and exciting equipment. It is necessary for a teacher to re-evaluate his teaching, to plan and prepare better, to experiment, and to work as a team with others. As television becomes more widely used and its full potential explored, a wonderful new tomorrow awaits the children in our schools.

I shall be delighted to exchange "tricks of the trade" with anyone who has had T.V. teaching experience and shall gladly welcome suggestions for the more effective use of this medium.

Closed Circuit TV Evaluation Sheet
Keene, New Hampshire
March 6, 1958

The following is part III and part IV of an evaluation sheet given to the biology students in the college preparatory group and in the general group. They were asked to give their biology grades at the close of the first semester.

The survey was tabulated according to those grades and by groups to see if any pattern were established.

III Do you feel that our CC-TV lessons have been worthwhile?

IV The future of closed circuit TV in Keene High School:

1. Do you recommend that biology be taught by CC-TV next year?
2. Would you like to have other classes taught by CC-TV next year?

BOOKS FOR BIOLOGISTS

GENERAL ZOOLOGY, Third Edition, Tracy I. Storer and Robert L. Usinger, 664 pp., $7.50, McGraw-Hill, New York, New York, 1957.

A sound understanding of the structure, function, and life characteristics of animals is provided by this book. Part I covers general principles of animal biology—structure, physiology, reproduction, heredity and genetics, ecology and distribution, and organic evolution. Part II provides a detailed survey of the groups of the Animal Kingdom, from the protozoans to mankind. This introductory text is exceptionally adaptable to differing course plans.

THE LIFE OF BACTERIA. Thimann, K. V. Macmillan Co., New York, 775 pp. 1955, $13.50.

An excellent college text or high school reference text on *The Life of Bacteria*, principally from a physiological point of view.

What Does a Fishery Biologist Do?

KENNETH D. CARLANDER
Department of Zoology and Entomolgy, Iowa State College, Ames, Iowa

As a teacher of fishery biology, I am often asked what a fishery biologist does. I sometimes find it a difficult question to answer because a fishery biologist may do many things. Let me give some case histories—from some of the students who have graduated from our school. Similar case histories could be presented by many other professors at other colleges. I take those from Iowa State College because these are the ones I know best. These are all case histories of young men who have left the classrooms within the last ten years. They are men with most of their careers before them—with chances of other experiences and of other accomplishments yet to come.

Bob is a fishery biologist for one of the midwest state conservation commissions. He is responsible for annual inventories of the fish populations in the streams of about one-third of the state. He needs to know whether smallmouth bass, channel catfish, trout, and other species are increasing or decreasing in numbers and size in the various streams. He therefore spends several weeks each year using trapnets, seines, and electric shocking equipment to collect fish for measurements and observation. He takes scales from many of the fish to determine their age and growth. Whenever there is a fish kill or suspected pollution in a stream in his area, Bob is called upon to test the water chemistry and the various aquatic organisms. Last summer he had two crews on a special project on a big river. These summer crews provide a fine opportunity for young students to find out whether they would like fishery biology as their occupation. Most states have such summer work available for a small number of interested students. In addition to his fisheries work, Bob may occasionally help out the game biologists in the commission with their pheasant work or at a deer checking station.

Harold works for a state commission on the Pacific Coast. Tuna investigations take all of his time. Each year he has spent a couple of months on board fishing vessels tagging tuna—one of the most difficult species to tag. At night at sea with a light and a dip net he has caught several rare specimen, including sailfish only 4 to 6 inches long.

Dick H. also spends a couple months a year on tuna fishing vessels, off the coast of Panama or Costa Rica, measuring and studying tuna. His work for the Inter-American Tropical Tuna Commission, a cooperative study established by a treaty between United States, Panama, and Costa Rica, includes trying to determine whether the tuna of different fishing areas are the same and move freely around the ocean or whether there are a number of separate populations which must be managed independently.

Lee was assigned to an area in the Southeast where the U. S. Forest Service was studying the effects of various logging practices on mountainous watersheds. His job was to determine for the state conservation commission the effects of these various practices upon the trout streams and upon the trout themselves. For three years he collected and analyzed samples of the water, of the food organisms in the stream beds, and of trout and other fish. Now, Lee is responsible for coordinating the fisheries research of his state. Each year he has also taken part in a fishing school which the commission holds to teach sportsmen better methods of catching fish.

In a neighboring state, Gene coordinates the stream fish investigations. Much of his work may be similar to that of Bob's who was first mentioned, but I refer to Gene because he has an adjunct to his main duties. He writes a nature study column for the monthly state conservation magazine.

Duane is quite an artist and prepares many of the illustrations and covers for his state conservation magazine. His main job is as coordinator of fishery management projects in the state. Many states separate the management projects, those that have to do directly with improving fishing and fishing habitats from

the research projects which find out how conditions are and how they may be improved. Recently Duane helped catch 7,200 large walleyes for transplanting to other waters when a lake went dry except for a few holes where the fish were crowded and starving. The remaining pools were such that seines and other gear could not be used. Duane and the others, therefore, had to catch the 7,200 walleyes by angling!

John M., capitalizing on his writing ability, is editor of a state conservation monthly and has a primary responsibility for promoting good conservation through education and organizational programs and over TV and radio.

Floyd is utilizing his fishery biology training as a biologist for the soil conservation service where he advises farmers on methods of utilizing their farm ponds and waste areas to provide fishing, wildlife, and recreation.

John L. is in charge of several research projects testing methods of increasing fish production in farm ponds. Much of his work now deals with methods of controlling aquatic plants and of preventing their clogging small lakes.

Bob is wildlife extension specialist for a state college and trains teachers, camp directors, 4-H leaders, and others in conservation and nature study. He is also on call to answer all types of questions in the conservation field and speaks on radio and TV at frequent intervals.

Only one of my former students went to work at a job that probably most people would first think of as a job of a fishery biologist. Jack became superintendent of a state fish hatchery and helped in raising trout for stocking purposes. He is now superintendent of fish propagation for a state.

Charley and John O. are in Alaska as Fishery Research Biologists for the Fish and Wildlife Service. Charley is working on the estimation of the numbers of salmon which run up the various streams each year. He and his co-workers are using many methods including counting the fish from towers or from airplanes and are experimenting with electronic devices which it is hoped can automatically record the fish as they move upstream. John O's research is largely on Kodiak Island where the early life of salmon in lakes is being studied. The investigations include the application of various fertilizers to these lakes to see whether the growth and survival of the salmon can be increased. John occasionally sees the magificent Kodiak bears while on his field trips.

John H. is on the sea lamprey investigations on the Great Lakes and has carried on several of the experiments which have led to the development of a specific poison which will kill lamprey larvae without killing other fish. It is hoped that this new toxin and the use of electric screens will control lamprey and permit a building up of the lake trout, whitefish, and lake herring fisheries again.

Gordon is a Fishery Marketing Specialist for the U. S. Fish and Wildlife Service, which means that he is responsible for collecting statistics on the catch by commercial fishermen and for measuring fish at they come to the docks. For a couple of years Gordon was assigned to collect data on the shrimp fisheries of the Gulf of Mexico. Now, he's collecting the Great Lakes fishery data.

Mike, because of his statistical methods training, is called upon to advise on many projects of the U. S. Fish and Wildlife Service. He is now working on several reports which are to be presented to the North Pacific Fishery Treaty countries (Japan, U.S.A., and Canada) to aid in their decisions as to how the commercial fisheries are to be controlled and as to which species need protection. Mike has worked with fisheries on both coasts for the U. S. Wildlife Service in the seven years he has been with them.

Arden went to work for the U. S. Public Health Service, studying the effects of various levels of pollution on fish and on fish-food organisms. Many of the problems of fish conservation are closely associated with pollution and with failure to maintain adequate supplies of clean water in our streams. After several years with the Public Health Service, Arden is now teaching biology in a university—helping to train new fishery biologists.

Dick W. has been on a special project attempting to establish a game fish population in Salton Sea. Because of its high salt content and its past history, this lake in southern California had no native fish. A forage fish, a Grouper, and a game fish, the Corvina, have now been established and in a few years should be providing successful fishing in a resort area previously devoid of fish. This

project is therefore closing soon – goal achieved.

All of the men that I have mentioned above are working for governmental agencies and this is characteristic of most fishery biologist jobs. There are relatively few private jobs because most of fish conservation is public.

Paul, however, works for a private corporation that raises and sells millions of goldfish and bait minnows. This private hatchery has several trained biologists to plan and build ponds and raceways, to feed fish and develop better methods of feeding them, to watch for and treat diseases and other causes of mortality, and to handle, sort, and prepare fiish for transportation. One of the latest wrinkles they have worked out is a plastic package in which a pair of goldfish can be kept for over two weeks. The plastic breathes –that is it lets air in and out without losing any of the water. Stores can thus sell prepackaged fish which can be carried home easily in the shopping bag.

Having briefly listed some of the things which a number of fishery biologists do, I hope that you will see why I cannot give a simpler answer to a straightforward question as to what a fishery biologist does. This listing could be made much longer but I believe that it is fairly representative.

A fisheries biologist may be called upon to do about anything that has to do with learning about, conserving, or improving aquatic resources. Most fisheries biologists spend part of their time "in the field" collecting data. This collection of data may involve chemical tests of water, sampling of bottom deposits for food organisms, fishing with various types of gear, measuring hundreds or thousands of fish, dissection of fish for food analysis or parasite infestation. tagging fish, and interviewing fishermen. It is this field work which attracts most men to the job.

There is, however, also a lot of desk and laboratory work for most fishery biologists. Field data are of little value until they are analyzed and until reports are prepared. Picking the food organisms from the sifted debris of bottom samples, identifying and counting plankton organisms (the microscopic and near-microscopic animals and plants that live in the open water), examining the rings on fish scales to determine ages and growth rates, analyzing hundreds of measurements, can be tedious work, but it is often necessary work for a biologist.

Fishery biologists are also frequently called upon to help in the education field. Many of the things which biologists learn in their studies and research need to be explained to sportsmen, to school children, to administrators, to everyone. The more effectively the biologist can speak, write, and explain, the more effectively can he aid conservation.

How can a person get the education needed to be a fisheries biologist? All of these biologists had college training but not all had the same amount. Some had the usual four year college work with one or two courses in fishery biology and conservation. Most of them took one or two years of additional work leading to a Master of Science degree and a few of them have their Ph.D.'s. In their graduate work many of them received some financial assistance for the research which they did for the Iowa Cooperative Fisheries Research Unit, an organization sponsored by the College and the Iowa State Conservation Commission. Many state conservation departments believe that it is to their benefit to aid students in this fashion. They then get properly trained biologists, and also can have part of their research handled by the colleges.

Since the duties may be broad, the education and training should be broad. A fisheries biologist needs first of all a broad background in biology and in the other sciences–chemistry, physics, mathematics. Usually he does not get specialized fisheries courses until he is a junior or senior in college, and he may even wait until his graduate work. Anyone wishing to be successful should put his attention not only to his scientific training but also should develop all the skill he can in the communication fields and in getting along with other people. Probably more biologists and more conservation programs fail because of poor personnel relations than because of lack of scientific knowledge or ability.

Few fishery biologists know what a forty-hour week is. The salaries are low compared to the education, experience and responsibilities required. However, fisheries biologists are not a dissatisfied group. They enjoy their work. They feel that they are performing a valuable service–the maintenance of our fishery and other aquatic resources for the greatest good of us all–now and in the future.

Pine Hills Area – A Relic of the Glacial Age*

S. G. GLIDDEN BALDWIN
Physician, Danville, Illinois

The Pine Hills Area is also known as the Devil's Backbone Country of Indiana. It is one of the most unusual and remarkable natural areas of Indiana. Here in an area of less than 600 acres, we have more geological, botanical and ecological features preserved than anywhere else in Indiana.

Within a few miles of the flat prairies of Illinois with their Oak-Hickory climax forest we find an evergreen oasis of Yew, Pine and Hemlock. These three species are not common to Indiana. Yew is found nowhere else in the state, Pine only in the north along Lake Michigan and Hemlock only sparingly. I feel that these species are relic species in this area.

The Pine Hills Area is in the west central portion of the state not far from the Illinois border. It is easily reached over State Road No. 234 close to where this route crosses Sugar Creek over an old two-span wooden bridge, itself worthy of study. It lies on both sides of Sugar Creek in Brown township, Montgomery County, Indiana, about 12 miles southwest of Crawfordsville. Close-by and lying along this same Sugar Creek are two of Indiana's best-known state parks, Turkey Run, and the Shades, formerly called "Shades of Death," quite similar areas in many respects.

Local Map of Area

Description

The geological feature which has produced the rugged, incised terrain responsible for the climatic conditions necessary to preserve these species is equally interesting. The Devil's Backbones are several very narrow ridges with nearly vertical walls of sandstone extending out from a plateau. The gorges between them extend down in some instances 110 feet to the meandering streams which are responsible for this spectacular terrain.

These same streams have produced terraces covered with deciduous trees and shrubs, as well as evergreens, showing tree associations indicative of the physiographical ages of these ascending terraces. In the words of the late Dr. J. E. Potzger, of Butler University, "Botanically, this region exhibits a larger number of excellent and clear-cut ecological areas and associations than any other region in Indiana."

History

The Pine Hills Area has been privately worked by the Hasselman brothers and heirs since around 1910. The last Hasselman to reside on the place was Laurence, who used to take pleasure in guiding the "Profs," as he called them, over his land. He became quite interested and a good botanist. However, he had no use for picnickers, and he finally became so incensed against them that he started carrying a gun. When he pulled it on some innocent visitors he was finally incarcerated

*Presented to the American Nature Study Society at the American Association for the Advancement of Science Meetings in Indianapolis, December, 1957.

Top of Devil's Backbone
Only 6-ft. wide with 100-ft. drop on either side

Slabs of Borden Sandstone
Peculiar Vertical spalling-off

in a mental institution where he died around 1952. Since then the land has had no care but has withstood the ravages of time exceedingly well, as it is so rugged very few people have attempted its exploration, with the exception, perhaps, of a few local lovers as it is known as a great trysting place. I expect their interest is not such as would destroy the natural beauty.

I am happy to report that since I began writing this paper last October the Hasselman heirs have tentatively agreed to sell the tract to the Nature Conservancy, who in turn, will deed it over to the State of Indiana when the money is raised to pay for same. The Indiana division of the American Legion announced that they would raise the $15,000.00 necessary for this project. It is thought that the land will be added to the Shades State Park which it adjoins and which was likewise given to the State of Indiana by the Indiana American Legion about ten years ago. It is understood that the region of the Devil's Backbone country will be maintained as a wilderness area and all land under the 750 foot contour will not be developed.

Geology

The geology of the area is extremely interesting. Most of the northern half of Indiana, including this area, was covered by the last or Wisconsin glacier leaving a mantle of soil, sand and gravel which has been called the Tipton Till Plains of the Central Lowland Provinces. It is of a somewhat rolling nature.

However, Sugar Creek and its tributaries have so dissected the land of these three parks that they resemble the rugged topography of southern Indiana. In the Pine Hills Area, the meandering of two streams, Indian and Clifty Creeks, have produced six narrow "backbones" which jut out from the surrounding plateau like interlocked fingers, with deep canyons between them. At the bottom of these canyons lie the two streams still actively cutting their way through the Borden sandstone. The backbones are called Devil's Backbone, Turkey, Pine, Millcut, Baby and Little Eagle.

These ridges are composed of Borden sandstone 70 to 120 feet thick. The Borden is just below the Mansfield and both are the basal members of the Pennsylvania System in this part of Indiana. The principal outcropping rock of the Shades and Turkey Run Parks close by is the Mansfield which produce their spectacular scenery of huge cliffs and lookout points above Sugar Creek.

The Borden sandstone in the park has been divided into three zones or layers: The top (zone 3), 8 to 10 feet, is not found in many places but the layer immediately under it (zone 2) is a fossilbearing layer of crystalline coquinas and sandstone with many crinoid fragments, a few spirifers, platyceras, fenestellids, producteds, and at places, brachiopods.

This layer is porous and is the spring-bearing strata of the park. This spring water seeps out through deposits of glacial gravel; as at the east end of the Devil's Backbone, it has glued the pebbles together like cement, the water being highly charged with calcium bicarbonate. This formation is called tufa. Below this fossil layer is the main outcropping formation of the Borden or zone 1, the lowest layer.

The upper layer of this strata is harder with less shale interbedded and maintains the top of these ridges which overhang in most instances. The lower layers are softer with more soil and have a peculiar way of spalling off in thin but large, flat vertical slabs due to frost and freezing. This action together with under-cutting by the streams has produced these backbones. In some places the irregular cementation has resulted in marked differential weathering producing such phenomena as the "Honey Comb Rocks" at the junction of Clifty and Indian Creeks. Limonite concretions are seen in many places in the sandstone.

The paths are dangerous but exciting and interesting. Several viburnums are soon encountered and rare plants as Wintergreen. Most people follow paths to the various backbones. Devil's Backbone is perhaps the most interesting of all these ridges and is also famous historically. It is about 125 feet long, and 6 feet at its narrowest part.

Mill-Cut Backbone is also interesting, historically speaking, because at one time just preceding the Civil War, a 36 foot deep channel 10 feet wide was cut through the narrowest part of the backbone. Clifty Creek was then dammed and the water traveled through this cut to operate a woolen mill on the 32 foot drop it gained. There wasn't enough water, however, the year around, and the mill was soon moved to Bluff Mills where Road No. 234 crosses Sugar Creek.

The streams in producing these backbones and canyons have given us five very interesting ecological areas. One, old flood plains

Undercutting by Stream and Honey-Comb Rock

along the meandering streams wooded by mature trees in great profusion. We may refer to these areas as First Terraces. Two, Second Terraces, elevated above but adjacent to the first terraces. These are still older flood plains and are also wooded. Three, the Upland Plateau, or top, into which the canyons have been cut. Four, the Transition Slopes connecting the above-mentioned areas, and five, Steep Canyon Walls.

The Botanical Story

In the preceding I have described this remarkable area, the probable cause, and the present conditions. Now, I would like to take you with me on a botanical and ecological hike, starting along the fast flowing streams in the bottoms of these canyons.

The streams are clear and shallow and can be waded most of the year. The present stream banks are low, and where recent flood plains have developed, they are composed almost entirely of sand, gravel, small boulders and many fossilbearing rocks which have weathered loose and plunged into the streams from the higher ridges. Small toads, salamanders and ringnecked snakes are found among these rocks in the spring and early summer months. These flood plains, however, are nearly barren of botanical specimens, showing their recent origin.

However, if we climb up to the first terrace, 3 to 5 feet above the stream bed or present flood plain, we find numerous species of mature trees. While several of these areas exist, I have studied three in particular. Quadrat studies were made of the trees, shrubs, and vines in the usual manner, recording the number of each species found. An average of 35 species were found on the first terrace. The most common species were Sugar Maple, (Acer saccharum), Hornbeam, (Carpinus caroliniana), Leatherwood, (Dirca palustris), and various species of Grapevines, (Vitus sp.). They were found in from 81% to 100% of the total number of quadrats studied. Thus, these species would be put in "Group E" of Raunkiaer's Classification. Next most common were Beech (Fagus grandifolia), Green Ash (Fraxinus lanceolata), Rough-leaf Dogwood (Cornus asperifolia) and Poison Ivy (Rhus toxicodendron) which constituted between 61% and 80% or Class D. Over 45% were in the low frequency group between 1% and 20%, called Class A. Only 2% of total number of all trees were in Class E.

Let us now climb to the Second Terrace, 15 to 20 feet above those just studied. In two of the three areas studied, we find an average of 26 species in this older and more mature area. 4% of them are in Group E. The most numerous are Sugar maple, Hornbeam, Hop hornbeam (Ostra virginiana), Beech, Maple-leaf Viburnum (Viburnum aceifolium) and Dogwood (Cornus florida), all in Group E. In the third area studied, known as the Pine Grove, there occurs what appears to be a virgin stand of beautiful White Pine (Pinus strobus). Many of these pines measure 8 feet in circumference breast high and are 80 feet high. Interspersed with the pines are numerous large Hemlocks (Tsuga canadensis). These two evergreens are growing under the same conditions as found on the other two second terraces, so far as I could ascertain. But there must be a difference in soil moisture or some other explanation. This grove is one of the features that makes the Devil's Backbone Country so interesting. White Pine is only found in this particular region (along Sugar Creek in Indiana) and far to the north in the Dunes adjoining Lake Michigan. Because of this disrupt distribution and the fact that White Pine does not occur farther west or south, I believe it should be called a relict species.

As we climb the steep slopes of these backbones to the Upland Plateau, there are many areas that exhibit transitional characteristics between the lower second terraces just studied and the Plateau top. Quadrat studies reveal that as we pass from the predominate hardwoods of the first and second terraces upward we first encounter Hemlock as a dominant species, and as we climb higher, we add White Pine still higher, as we approach the top. Hemlock drops out leaving Pine to continue alone representing the evergreens. We pick up two additional hardwoods near the top, Dogwood and Viburnum. On the very top we lose the Pine and end up with hardwoods again with Sugar Maple and Beech, etc., the most numerous species.

There is one slope as we take the path downward from the top of Turkey Backbone to Clifty Creek that is nearly a pure stand of Hemlock. There are a few pines at the top and a scattering of deciduous trees that are barely holding their own. A carpet of Hemlock needles coats the ground. The area is open under the trees with few shrubs, the light is subdued, and you think you are transplanted to New England, for this type of a grove does not occur many places in Indiana or the central states, for that matter, as this is the farthest west outpost of Hemlock in this latitude. There is no Hemlock found west of here in Illinois which is only 45 miles away. East of here the Hemlock becomes more prominent and occupies the plateau tops associating with Maple and Beech, the three forming the climax forest of much of Ohio. Because of this disrupt pattern and its failure to be found farther west, I believe that Hemlock, in the Pine Hills Area, can likewise be called a relict species.

On the steepest north-facing slopes of 40 to 45 degrees we find another relict species, American Yew (Taxus canadensis). The north wall of Turkey Backbone is such an area. There are only 19 species found here and all of them fall in the low frequency group. Yew is so dense in this area that not much else can grow, abetted by thin soil, lack of sun and the moisture content. In Indiana, Yew is only found along Sugar Creek in the areas under discussion. The two closest stations where it can be found that I know

of, are the Sugar Grove region of Ohio, 175 miles east and somewhat south, and White Pines State Park in the northwest part of Illinois. Therefore, I consider that Yew is also a relict species in this area.

The Plateau Top area is an interesting area, and studies here reveal that almost all species are deciduous. The most numerous and widely distributed trees are Sugar Maple, Sassafras (Sassafras varifolium), Beech, White Oak, (Quercus alba) and Black Oak (Quercus velutina). There are altitudinal differences in this area. Of course, this is the oldest area physiographically, of all the areas we have studied. There are around 28 species, and only Sugar Maple and Sassafras are in group E. Beech occurs in practically all areas but not as a group E. In all areas studied throughout the Park, Sugar Maple is in class E except one place where Hemlock is so dominant that 90% of the balance of the species found here are in Class A. While there is quite a little Hickory found on top it never occurs in a higher group than C. There is plenty of White and Black Oak but very little Beech up on the plateau. Beech is likewise found very sparingly farther west in Illinois and then usually confined to slopes. Beech, of course, in the other direction, east, comes out more and more on the plateau tops and soon becomes part of the climax forest in Ohio with Sugar Maple, and at many places, the climax also contains Hemlock as a co-dominate, whereas farther west the usual climax is the Oak-Hickory of the prairie. I believe that Sugar Maple alone is the dominant species and forms the climax forest of the Plateau in the Pine Hills area.

From these studies and from the literature I have read, I find several interesting conclusions: Hemlock occurs most frequently in the transitional areas on steep slopes. White Pine occurs on the same steep slopes but in greater frequency, closer to the top. The exception is the beautiful Pine Grove described as area 8 which may be likened physiographically to a second terrace. Yew occurs on the very steep north slopes, in some places so abundantly, it crowds out most other species.

As like areas of the same topography become older the number of species decrease, and there is a decrease in the percentage of low frequency species and a rise in species of high frequency.

These conclusions suggest that as soon as a new land area becomes stabilized and free of floods and major climatic changes, many species are seeded in by natural agencies and most of them get a foothold and survive for awhile.

As the same topographical areas become older and reach maturity those species better adapted to the existing conditions crowd out the others which fail to maintain their stand, thus also reducing the total number and increasing the frequency of those remaining. It is apparent in this natural laboratory that all these various species of woody plants start out equal; that the conditions of environment are suitable is witnessed by the fact that most all these species continue to propagate themselves on the newer areas or first terraces. Therefore, conditions are suitable for growth, and it is the rigorous competition that ensues over many years and generations of these plants for the soil, water, sunlight and space that determines the survival of those left. I believe White Pine, Hemlock and Yew are relict species in this area and the present climax forest appears to be Sugar Maple.

At the time of the recession of the last glacier from the area of Pine Hills, the flora no doubt consisted almost entirely of evergreen trees and shrubs.

I quote from a personal communication from William J. Wayne of the Indiana Geological Survey.

"The moraines of Montgomery County are part of the complex Bloomington morainic system, named from Bloomington, Illinois. They appear to represent end moraines of a rather extensive readvance of the ice during the Tazewell (early Wisconsin) substage. Large quantities of outwash gravels and sands are associated with this stage in the glaciation of Illinois, Indiana and Ohio. Many of the present streams of central Indiana appear to date from this last fluctuation of the Tazewell ice sheet.

'At the time that the Bloomington moraine was being constructed, the region along the outer ice margin undoubtedly had a sub-arctic climate. Very likely a narrow belt of tundra vegetation marked the area immediately in front of the ice, although no positive evidence of this has ever been discovered in Indiana or the adjoining states. A spruce-fir maximum is the first vegetation of which we have evidence from pollen analysis.

'The few bogs in southern Montgomery County might yield pollen that would indicate the climatic and vegetation sequence in that region if they were to be properly sampled. As far as I know, the relict flora of that region occurs on the steep, north-facing slopes of valleys. This would tend to indicate that sufficient erosion had taken place to provide such a habitat while the area was still under glacial influence, although the relict floras may date from one of the later ice advances which were restricted to somewhat farther north. Surely a continental ice advance into central Michigan would have moved the pine-oak boundary southward. Enough erosion may have taken place between Tazewell and Mankato time to provide a virtually sunless northern slope in many ravines."

As the climate became warmer the broad-leaf trees were re-seeded into the area coming up gradually from the south and east, perhaps all the way from their sanctuary on the Cumberland plateau or the adjacent region of the Great Smoky Mountain country. The evergreens could not compete in this warmer and changed climatic conditions and followed the melting glacier to the north where they are still to be found as climax species. But here in the Devil's Backbone country the topography was so changed, by the unusual meanderings of the fast-flowing creeks already described, and favored by the peculiar geological formation of the Borden sandstone, that a climate had developed locally in these incised valleys in which Pine, Hemlock and Yew could and did survive continuously since the time of the last glacier to the present, making them relict species in this region.

We might conjecture that in the distant past, after the spruce-fir forest had receded, White Pine may have been the dominant species in the Park, and as the valleys grew deeper and deeper between these backbones, and the climate and moisture content changed, and the slopes became steeper, Pine could not compete with Hemlock which invaded these slopes, replacing the Pine on the lower slopes, and probably became dominant. Still more recently we have seen the Beech and Maple assume dominance and another invasion taking place by these hardwoods giving us a Hemlock, Beech, Maple climax which was succeeded in turn by the present climax of Sugar Maple alone.

Growth and Variability—A Laboratory Experience

JOHN E. BUTLER
Assistant Professor of Biology, Fresno State College

Perhaps the most distinguishing feature of living material is its variability. It is a paradox of the biological sciences that this is at once its most interesting and yet its most trying characteristic. Under the present system of teaching biology in many schools, time does not allow a presentation of the dynamic nature of living organisms. The teacher is faced with the necessity of presenting a large amount of factual material in order to establish a firm background in the sciences. Consequently, little time remains for a discussion of the variables relative to these facts. As a result, the beginning student, upon completing his first course in biology, is left with the impression that the factual material and concepts of biology are static and agreed upon by the more advanced students of the subject. Such a view is unfortunate and in direct contrast to the spirit of the science.

It is felt that the following experiment may help to alleviate this condition by stressing the dynamics of plant growth and the variability among individuals. The natural inquisitiveness of the student can be exploited by the adventure of setting up an experiment and of making routine observations, the assembling of these results and the forming of conclusions regarding growth processes.

The common bush bean is a good plant for this experiment because it has a large seed, grows rapidly, is easily obtainable, and the emergence of the young plant by elongation of the hypocotyl is somewhat spectacular. The first variability may be pointed out in a handful of seeds selected at random; close inspection will reveal that the seeds are not uniform in size. Once recognized, this factor of variability can be eliminated by selecting seeds of a uniform size for use in the remainder of the experiment. A number of these selected seeds are placed in an oven at 100°C for 24 hours, and weighed to determine aver-

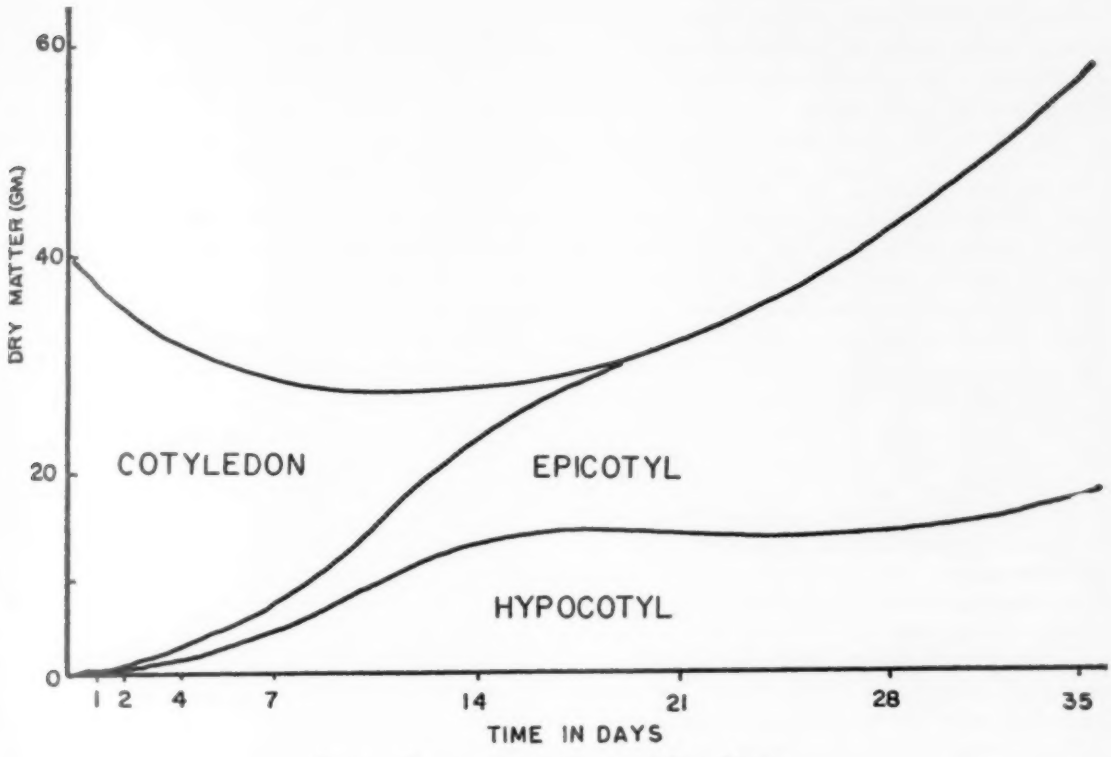


FIG. 1. Changes in Distribution of Dry Matter

age dry weight. The remainder are weighed before being germinated. Then these seeds are germinated in a moist chamber for 24 hours (blotting paper or rag germinator will serve for this purpose). Although the seeds are approximately the same size, the time periods required for germination show a wide range of variability, and here again the variation may be noted. Only those seeds in which the hypocotyls have just pierced the seed coat are planted; if the hypocotyl has elongated more than one millimeter the root tip may be injured in planting.

The number of pots used can be adjusted to the time available to the instructor and students and the space available in the greenhouse or other facilities. A typical plan is presented in the following discussion. Thirty pots were planted with four seeds each. At intervals three pots were selected at random and the roots were washed free of the soil. This was accomplished by turning the pot upside down and giving the pot a sharp tap. The plants and soil came free from the pot and could be easily held in one hand. A stream of water washed the soil away with little trouble. In order to keep the plumbing free of soil, the plants were washed in a bucket so that the soil would fall to the bottom and the excess water could go down the drain. Then the plants were separated into three parts: the cotyledons, those parts derived from the hypocotyl, and those parts derived from the epicotyl. These were weighed to give fresh weight and then dried for 24 hours in a 100°C oven and weighed again to determine dry weight. In these experiments, wet weights were taken only for the first two weeks. This was to show the large amounts of water taken in by the plant during the first few days of growth.

The first measurements obtained were the wet and dry weights of the seeds as they came from the store. This gave the initial figures as well as the percentage of water in a resting seed. The next weights were taken from those seeds which had been placed in the moist chamber for 24 hours. Thereafter, plants were removed at intervals of two days, four days, seven days, and weekly intervals.

There are probably several good ways to present the results. As the experiment prog-

resses a simple table showing the weights should be prepared to illustrate general trends. However, to visualize properly the growth of the plants and the shift of stored material from one organ to the other, it would seem that a composite graph as shown in Fig. 1 is important. Here, in one place, the students are able to see how rapidly the total dry weight goes down until, at two weeks, it is only about 60 per cent of its original weight. At the same time one can follow the shifts in weight. We have converted to a 100 seed basis for convenience.

From the above experiment on the growth of the common bunch bean we can derive the following generalizations. The first structure to emerge is the hypocotyl followed shortly afterwards by a rapid establishment of the root system. Several inches of roots will be produced before the cotyledons rise to the surface of the soil. This latter phenomenon is seldom observed and therefore seems startling to the students. From Fig. 1 we see that there is a loss of dry weight of the growing parts. This shows that digestion has broken down the stored food, which, in turn, has supplied the energy necessary for growth as well as most of the building material for this early growth.

After the establishment of a root system and the subsequent absorption of nutrients, a rapid growth of those parts derived from the epicotyl is noted. This requires energy and material with which to build. The major part of these requirements is supplied by the cotyledons; this may be demonstrated by observing a loss in weight of the cotyledons. With the increase in size of the seedlings the stored material from the cotyledons is used at a more rapid rate. By the time the first pair of simple leaves are fully expanded (approximately 10 days) it can be seen that the rate of loss of weight begins to decrease and finally a point is reached where there is no further loss of total weight. The leaves are now producing sugar by photosynthesis, and it seems that the compensation point has been reached; the food required to replace the needs for growth plus respiration is just replaced by that amount produced by photosynthesis. In a few days the second internode starts to elongate and with it the expansion of the first trifoliate leaf. As more leaves are developed the total dry weight increases rapidly.

It will require approximately four to five weeks for the plants to return to the initial dry weight. By this time, however, the plants will have reached the grand period of the growth curve. Up to this part the experiment will produce the typical flattening of the growth curve. However, if the experiment is being used to show the transfer of the material from the cotyledons to the growing parts of the seedling it might be well to end the experiment at this time.

If it is desired another series might be grown in darkness. The etiolated seedlings selected at the same time interval will show a continuous decrease in weight since the organic materials used in respiration are not replaced by photosynthesis. It might be well to point out that the increase in dry weight is not correlated with growth by expansion. The etiolated seedling will soon die so this part will be completed in about three weeks.

BOOKS FOR BIOLOGISTS

A KEY TO THE STARS, Third Edition, R. Van der R. Wooley, 144 pp., $4.75, Philosophical Library, New York, New York, 1956.

This is a book for the non-specialist, recounting in simple terms not only the main facts of astronomy as they are known today, but the reasoning and techniques which have led to their acceptance.

GENERAL ZOOLOGY, Mary J. Guthrie and John M. Anderson, 708 pp., $7.50, John Wiley & Sons, Inc., New York, New York, 1957.

The opening chapters of this book deal explicitly and thoroughly with structure, function, and biological principles as illustrated by vertebrate animals. The structure and activities of cells are discussed with the newer knowledge from biochemistry and electron microscopy, against a background of classical microscopy and the cell theory. The latter part of the book considers general topics such as heredity, classification, ecology, and evolution, and devotes a chapter to each of the major groups of invertebrate animals and to the chordates.

HUGH ROY CULLEN. Kilman, E., and Wright, T. Prentice-Hall, Inc., New York, 376 pp. 1954, $4.00.

Hugh Roy Cullen's life story substantiates the fact that opportunity in America is still alive, that the individual is important, and that faith is a vital ingredient in successful living.

Biology Field Trip – One Foot Away

MURVEL R. GARNER
Professor of Biology, Earlham College

Biology teachers often feel frustrated at their own inability to arrange appropriate field trips. The nature of the subject matter demands an acquaintance with living forms in their natural habitats. Yet the limitations of the fifty-minute period and the departure of the bus at three-thirty drives many of us to become, more and more, laboratory and textbook teachers.

It is in the search to meet this difficult situation that the idea of a field trip—one foot away, has come to me. The "one foot away" applies to an intelligent examination of the soil which may be directly under foot.

By way of preparation it can be pointed out that there are two great realms of life—above and under ground. We are separated from the latter only by the soles of our shoes, but we see virtually nothing of the dramatic roles played by living things in the subterranean realm. A preliminary study will remind us that earthworms are drilling holes "down there," how or why we are not too sure; ants are nibbling away at the walls of cavities, thereby enlarging them; tiny mites, nematodes, springtails are chewing at the decaying matter of old roots, thereby clearing the channels to become well-travelled highways and more effective drainage ditches; seventeen year cicadas are wandering vaguely about awaiting the expiration of their long sentences before escaping from their underground prisons; rabbits and woodchucks burrow short distances into the dark and mysterious soil. But the real mass of activity is poorly understood.

The following studies, observations and experiments were devised to throw more light on this dark region under foot.

Latex casts of tunnels. In order to make a cast of the various types of cavities and tunnels made in the soil, liquid latex is excellent (Garner 1953). It is poured into the soil that has been tunnelled, until the soil will hold no more. It is allowed to congeal for a couple of days and the lump of soil is dug up; the soil particles are washed away with a stream from a garden hose; the latex mold shows clearly the glazed tubes of earthworms, the "nibbled" cavities of ants, and the irregular voids of shrinkage cracks.

Feeding habits of earthworms. For these experiments a series of "cores" of puddled earth treated with alfalfa meal to increase the growth of molds (Garner and Telfair 1954) are buried a few inches below the surface of the ground. Cores were dug up at intervals and examined for earthworm feeding. As molds developed, worms were attracted and the cores were literally eaten away. Cores allowed to remain longer serve to demonstrate the invasion by roots, also, the flaking action of physical agents, wetting and drying, and freezing and thawing, in the ultimate breakdown of the cores. Thus an interpretation can be made of the various physical and biotic agents that contribute to the changing of soil.

Excavation of an ant hill. For this exercise a hole is dug just to one side of a thriving ant hill. Then the dirt is chipped away nearer and nearer the ant's nest until the cavities and tunnels are revealed. Frequently ant hills seem to consist of many small villages rather than one large city.

Population studies of earthworms. Some writers have said that the earthworm is the "most important animal in the world" as it improves the soil. A cubic foot census can be translated into population per acre of comparable soil by multiplying by 43,560 the number of square feet in an acre. More advanced students may become interested in the identifications of earthworms by species and their special ecology. Actually, most of us may find from a dozen to thirty species.

Microfauna of the Soil. Soil may be searched for microfauna, mites, springtails,

Garner, Murvel R., The Preparation of Latex Casts of Soil Cavities for the Study of Tunneling Activities of Animals. *Science*, October 2, 1953, 118: 380-381.

———and David Telfair, New Techniques for the Study of the Restoration of Compacted Soil. *Science*, October 22, 1954, 120: 668-669.

Specify DIFCO *. . . the only complete line of microbiological reagents and media*

Culture Media
Microbiological Assay Media
Tissue Culture and Virus Media
Serological and Diagnostic Reagents
Bacterial Antisera and Reagents
Sensitivity Disks Unidisks
Peptones Hydrolysates Amino Acids
Enzymes Enrichments Dyes Indicators
Carbohydrates Biochemicals

Over 60 years' experience in the preparation of Difco products assures
UNIFORMITY STABILITY
ECONOMY

Complete Stocks
Fast Service *24-hour Shipment*

Difco Manual and other descriptive literature available on request

DIFCO LABORATORIES
DETROIT 1, MICHIGAN

TRIARCH PRODUCTS

Fine Microscope Slides for Discriminating Biologists

More than 1,000,000 Triarch Slides have been sold to over 1200 Colleges and Universities throughout the world. Ask them for an appraisal!

***

For current Catalog No. 11, write to:

GEO. H. CONANT
Ripon, Wisconsin

beetle larvae, etc. by use of a hand lens, or a modified Berlese funnel which includes a light bulb, heat from which drive the animals into a funnel at the bottom of which is a bottle of preservative. Many unusual sorts of animals may be taken in this way.

Important as budgets and equipment are, I am convinced that there is a great deal that can be done using materials that are right at hand for the better understanding of life processes and interrelationships.

Why do muscles lose strength and joints get stiff in old age? New insights into such diseases as arthritis and hardening of the arteries and such processes as growth and aging are offered through extensive research on collagen —the fibrous material that holds the body's joints together and its organs in place. A new technique for chopping away at the complex collagen molecule and thus revealing secrets of its structure was reported by Mrs. Susan Michaels-Epstein, a research associate in the Department of Medicine of the Long Island Jewish Hospital.

Collagen is formed of about 3,400 amino acids, of 17 different types, linked together. Chemists have ways of identifying amino acids—the basic building blocks of all protein —but the challenge of this work is to determine how these units are joined. The researchers found and purified a specific tool for breaking up the collagen molecule into fragments that could be analyzed and thus give clues to the overall structure. The tool for cutting the collagen molecule down to size is the enzyme collagenase, obtained from a tiny micro-organism. By use of collagenase, the collagen molecule has been shown to be about one-third glycine, the simplest of all amino acids.

Aid in combatting eye disorders in human infants may be a by-product of research promising to increase the hatchability of turkey eggs. The high incidence of eye cataracts found in the offspring of breeder hens on standard feed did not occur in the embryos from the vitamin E-fed group.